**University of Minnesota**

**School of Physics and Astronomy**

# Physics 4052 Lab Manual
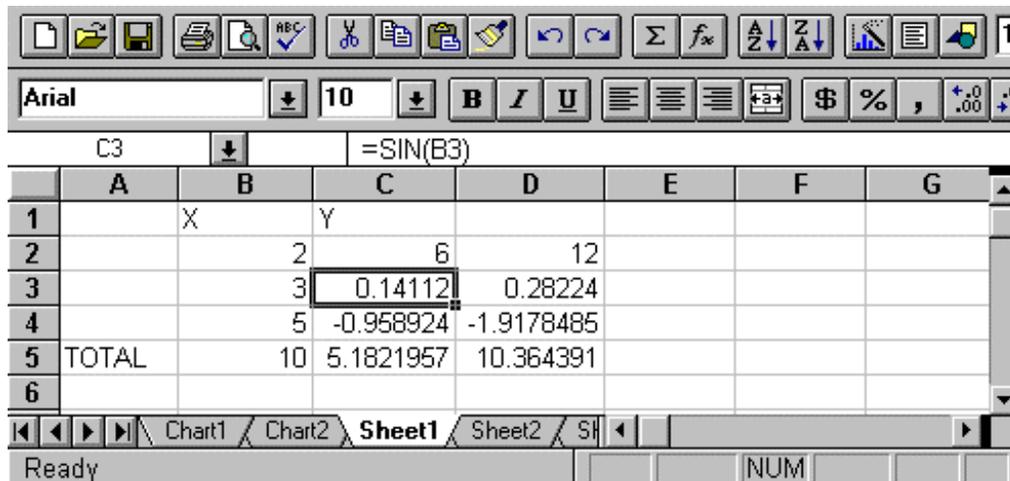
Spring 2001

# Excel: Spreadsheets

## C.1. How To Get Started

The spreadsheet currently used in the lab is Microsoft Excel 97.  To start Excel either:

Select it from the START / PROGRAM / Microsoft Excel menu;

Or click double click on the Excel icon (shown on your right) on your desktop.

You should see the spreadsheet screen similar to the one shown below.



- Figure C.1.

You may enter a value in a cell by selecting the cell (click on it with the mouse pointer) and then start typing.  To edit a cell, click on it, press F2 to activate it and then edit it.

## C.2. Basic Concepts

### Cell Addresses

The spreadsheet consists of cells each having its unique address consisting of the row and column position it occupies.  Note that the row addresses use numbers while letters are used to specify the columns.  For example, cell C4 refers to the cell in the spreadsheet in Figure D.1 that contains the value -0.95892.

## Cell Contents:  Constants and Equations

A cell may either contain a constant or an equation (sometimes also referred to as "formula").  The difference between the two is whether the object is preceded by an equal sign:  anything preceded by an equal sign is considered an equation, anything else a constant.

### Constants

Typical constants in a spreadsheet are text labels such as cell A5, "TOTAL."  Any number entered that is not preceded by an equal sign is also considered a constant.

### Equations (or Formulas)

Though the sample spreadsheet above contains numerous equations they can not be seen because equations are normally not displayed.  Usually, the computer executes the equation and displays only the resulting value.  Figure D.2 is a picture of the same spread sheet as shown in figure 1 but revealing the "real" contents of the cells:
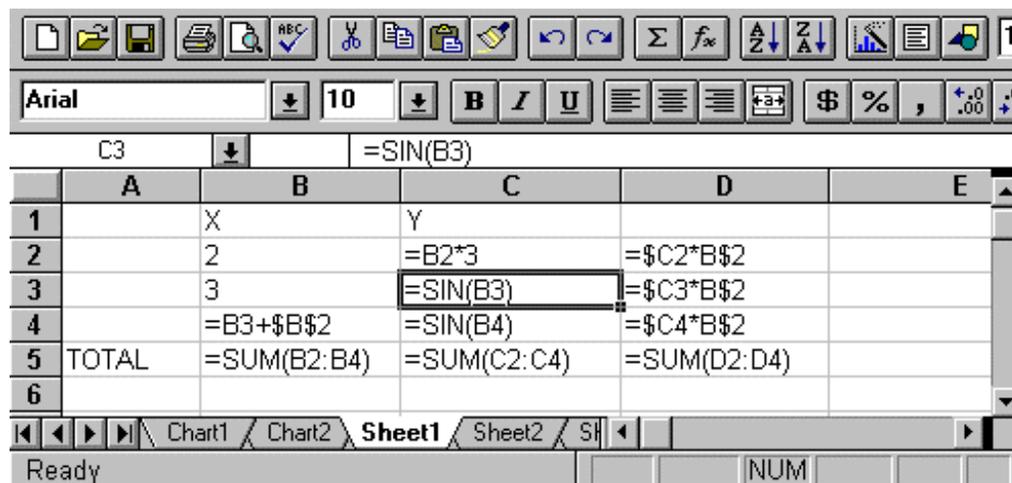


• Figure 2

As you can see now, the majority of the cells actually contain equations.  For example, all cells in column D contain equations while cells B1, B2 and B3 contain constants.

If you want to see the content of a particular cell just move the cursor to that cell and the "real" content of that cell is displayed in the window above the column headers.  For example, as you can see from figure 2, cell C3 contains the equation: =SIN(B3).  This information is normally displayed in the window directly above the column header (see figure D.1).

## More Cell Addresses

The majority of the cells in a typical spreadsheet usually contain equations.  Though such equations do not have to relate to values stored in other cells (for example: =2*7 is perfectly OK) most equations do.  When an equation refers to a value in another cell, it can do so using an absolute, a relative or a mixed reference for the address.  As long as you do not move or copy a cell referring to another cell, the way absolute and relative addresses function are identical.

### Absolute Reference or Address

To make a reference absolute, it is preceded by a dollar sign.  The address can be absolute with respect to the column (for example: =$C4), the row (for example, =C$4) or both, colon and row (for example =$C$4).

### Relative Reference or Address

Any address not preceded by a dollar sign is relative.  As previously mentioned, addresses may either be entirely relative, (for example: =C4) or they can contain both absolute and relative references.

### Address Range

For certain mathematical functions, an entire range of cells can be specified.  This is indicated by inserting a colon between the starting cell and ending cell, for example A5:C9 indicates all cells in the range from and including A5 to C9.  As you can see, though most of the times a range only spans part of a column or row, it can span multiple columns and rows.  Another example is shown in cell B5, figure2, which adds the contents of cells, B2, B3 and B4.

### How to Enter the Address in an Equation

Two methods exist:  First, you click and move to the appropriate cell and then type the equation with the necessary address.  This is difficult because it's easy to mistype the address.  A better method is, to move to the cell and enter the equation till you have to enter the address.  At this point move the cursor to the actual cell that you are referring to and hit return; the computer will automatically insert the address into the equation.  If you are referring to a range of cells you can select those directly by moving the cursor to the first cell, then while holding down the shift key, move to the last cell in the range.

## Copying

As previously mentioned, the difference between absolute and relative addresses becomes apparent when copying the content of a cell to a different location.

### Copying a Relative Address

Consider the following example:  we want to multiply by 2 all constants in column A and store the results in column B.  As you can see from the spreadsheet in table 1, we have already entered the corresponding equation in cell B5.

|   | A | B | C |
|---|---|---|---|
| **5** | 5 | =2*A5 | |
| **6** | 6 | | |
| **7** | 7 | | |

- Table 1  (Note:  these and the following tables display what is stored in the cells, not what the computer would display on the screen!)

Instead of entering subsequent equations in cells B6 and B7 we decide to copy the content of cell B5 into B6 i.e. we use Excel's copy/paste feature.  When we copy the content of cell B5 into cell B6 the following happens:

|   | A | B | C |
|---|---|---|---|
| **5** | 5 | =2*A5 | |
| **6** | 6 | =2*A6 | |
| **7** | 7 | | |

- Table 2

Though we expected cell B6 to be =2*A5, the computer automatically updated the referring address because it was a relative reference.

When copying cells with relative addresses to a different location one should read them like: this reference is in regard to the cell directly to the left; multiply its content by 2.  In other words, when copying relative addresses the computer will do some thinking for us.

**Copying an Absolute Address**

Now we repeat the example shown in table 1 using an absolute address:

|   | A | B | C |
|---|---|---|---|
| **5** | 5 | =2*$A$5 | |
| **6** | 6 | | |
| **7** | 7 | | |

- Table 3

When the content of cell B5 is copied into B6, the address remains unchanged.

|   | A | B | C |
|---|---|---|---|
| **5** | 5 | =2*$A$5 | |
| **6** | 6 | =2*$A$5 | |
| **7** | 7 | | |

- Table 4

**Warning About Copying Data to Different Places in a Spreadsheet!**

Though these examples appear rather trivial they lead to a very important point.  What is shown in the above tables is not what you would normally see on the computer screen because the computer displays only the results from your calculations and so you don't know if the results were obtained using constants, or formulas with either absolute or relative addresses.  Therefore, if you copy a data to

another place in the spreadsheet or to another spreadsheet using the copy/paste feature, the copied data may not be the same as the original. This is almost always the case if the data your copying has relative addresses.

You have two options to avoid this problem. Either make the addresses in the original data absolute; this can be annoying at times because you have to go back and change your equations. The second approach is to use the **copy/paste special** feature: **values**. If you use this feature, the program copies the equations, evaluates them and finally only stores the resulting values as constants in the new location.

## Making Multiple Copies: Filling in

### Filling in: Fill Down, Fill Right

So far our examples for copying cells have been more for illustration purposes and have not yet revealed the power of spreadsheets. Most of the times, we do not just want to copy one cell but a whole range of cells. For example, going back to table 1, if we could copy the first cell multiple times in one keystroke then we could multiply all values in the first column. The process of copying a cell multiple times is called filling and depending if it is done in a row or column, it's called **fill right** or **fill down**. The fill-process involves three steps:

1) enter the equation or constant in the first cell that you want to be duplicated

2) select an adjacent range of cells into which the equation or constant will be copied. (To highlight or select, move the cursor to the first cell, hold down the shift key while moving the cursor to the last cell in the range.)

3) select the "fill down or fill right" feature under the EDIT / FILL menu or as short-cut, press CTRL-R or CTRL-D, respectively.

### Filling "in" Equations Containing Relative Addresses

Let's repeat the example in table 1. After having entered the equation in the first cell, (B5), we select or highlight cells B5:B7. After having selected fill down, the spread sheet looks like:

|  | A | B | C |
|---|---|---|---|
| **5** | 5 | =2*A5 | |
| **6** | 6 | =2*A6 | |
| **7** | 7 | =2*A7 | |

- Table 5

Note how all the relative addresses are automatically updated

### Filling "in" Equations Containing Absolute Addresses

If we use a fill-down on the example in table 3, all cells would be filled with the equation: = 2*$A$5.

### Filling "in" Equations With Containing Relative and Absolute Addresses

For a more advanced example consider what happens if we decide to fill down a "mixed" referenced address. For example we want to multiply the values in column A by a value at the top of column B.

| | A | B | C |
|---|---|---|---|
| **5** | | 2 | |
| **6** | 5 | =$B$5*A6 | |
| **7** | 6 | | |

- Table 6

The equation in cell B6 of table 6 could be filled down and would produce the desired effect. What about if we want to multiply column A with various constants specified in row 5? Certainly we could enter in cell C6: =$C$5*A6 and a similar equation in column D. This is cumbersome. A better way is shown in cell B6, Table 7:

| | A | B | C |
|---|---|---|---|
| **5** | | 2 | |
| **6** | 5 | =B$5*$A6 | |
| **7** | 6 | | |

- Table 7

Now we can both fill the value in cell B6 down and right and with very little effort set up the following table:

| | A | B | C |
|---|---|---|---|
| **5** | | 2 | |
| **6** | 5 | =B$5*$A6 | =C$5*$A6 |
| **7** | 6 | =B$5*$A7 | =C$5*$A7 |

- Table 8

## C.3. Advanced Topics

### Equations

Excel has an extensive library of advanced mathematical and statistical functions. The ones most often used are:

=if( condition, A, B)    if condition is true, A will be executed, else B

=sum( RANGE ) totals all values for cells specified in RANGE

=max( RANGE ) finds the largest value for the cells specified in RANGE

=min( RANGE )  finds the smallest value for the cells specified in RANGE

=count( RANGE )     returns a number indicating how many cells in RANGE contain values

=average( RANGE )  calculates the average for the cells specified in RANGE

These are just some of the many functions that are provided.  For a listing of the functions and their use click on the "function wizard" button, $f_x$ .

## Graphics

### To Create Graphs

It's very easy to make graphs:  select or highlight the data and then use the charting options to plot it.  If you should change your data, Excel automatically updates your graphs also.

There is a "chart wizard" button but it can be cumbersome.  Instead, use the direct step by step approach to create charts:

1)   Select the columns or ranges (hold down the CTRL key if selecting non adjacent columns) containing the data and any header that you want to plot.  Do not select any data that you want to use for errors bars, i.e. your  $\sigma_i$.

2)   Select:  **Insert, Chart**.

3)   A menu will guide you through different charting options; select the ones you want.  If you want to plot $x$ vs. $y$, which is the case most of the time, then select **XY (Scatter)**.  **Warning**:  if you select **Line graph** instead, the x data will not be plotted but appears instead as evenly spaced labels along the x-axis!  Be careful!  Go to the next panel by clicking on NEXT.

4)   The next window displays the data range selected for plotting and confirms that the data series are stored in columns rather than rows.  Usually, you do not need make any changes in this window.

5)   Go to the next panel, which will give you the option to enter chart titles and axis labels.  Proceed to the next panel.

6)   In this panel, you have to choose if you want the new graph to be inserted as a new sheet or as an object in the current spreadsheet.  Always select *As New Sheet*.  Do not *select As Object in…* because this generally leads to tiny charts that are difficult to see, annoying to resize, place and print.  Select "FINISH."

7)   You should see a new tab added to your worksheets, by default called CHART1, containing the new graph.  To view your spreadsheet again click on the tab on the very bottom of the chart, most likely it will say *Sheet1*; to go back to the chart click on *Chart1*.  You can change these labels by double clicking on them.

### Adding Error Bars to Your Graph

To add error bars to your graphs, in your spreadsheet (ideally adjacent to the real data) add a column with the $\sigma_i$ for each data point:

1)   With the **right** mouse button click on any data point in your graph; once selected the color of the data points will change and a menu appears.

2)   On that menu, select: **Format Data Series**.

3)   Click on the *Y-Error Bars* tab.  A window like the one shown below is displayed.
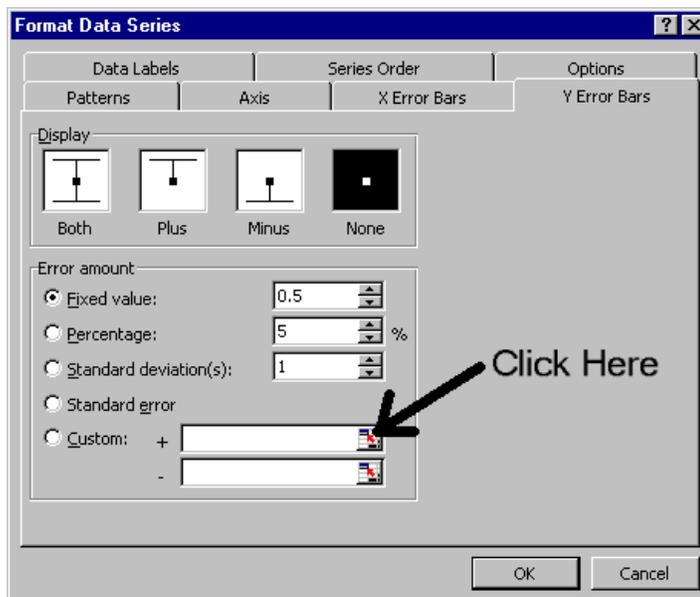


4)   Click on the colored button that the arrow in the above picture points to.  A new window called *Format Data Series Custom +* will open.  See below.



5)   Select the worksheet containing the data with the $\sigma_i$: Select it, by clicking on its tab, at the bottom of the chart.

6)   On that sheet, highlight the $\sigma_i$.  Note that the address range is automatically filled in *the Format Data Series-Custom+* window as shown above.

7)   In the *Format Data Series-Custom+* window, click on the colored button to the right, directly below the "x" button.  It will return you to Y-Error Bars window.

8)   Click on the colored button in the *Y-Error Bars* window directly below the one you just clicked on, i.e. the one to the right in the *Custom - window*.  A new window *called Format Data Series Custom -* will open.  Repeat steps 4 through 7.

9) When done, click Enter in the *Y-Error Bars* window.  Your graph should now display the appropriate error bars.

Note:  make sure you match the $y_i$ and the $\sigma_i$ .  If the addresses are not matched, strange stuff can appear on the graph.

**Adding a Trendline to Your Data**

Though Excel has some line fitting capabilities, you should use these with great care! They are only useful in that they give you a quick, first glance at the data. For more serious fitting, use your own program! Anyway, here it is:

1)   Just like in step one for selecting the error bars, click on one of the data points in the chart.

2)   Select in the *Add Trendline* menu and select the type you want, i.e. usually linear.

3)   Click on the *Options* tab and select *Display Equation on Chart*.

4)   Since the font size for the displayed equation is very small, click on the equation, click on *Font* and then Increase the *Size* to 20.

## Basic Tips:

**Do Not Start a Spreadsheet at Cell A1!**

Always leave a few columns to the right and a few rows on top free. As you will work on your spreadsheet, they will come in very handy because you may want to add something. In case you do not need them, delete them when you are done.

**Always List the Results in the Top Rows!**

You will have to break with the habit of listing your results at the bottom of a column. Unless the columns are very short, always display your results on top. If you list them on the bottom, you or the user has to go searching for them; if they are on top, they are visible and easy to find.